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Long-term variability of the North Atlantic Current system in a realistic simulation

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The North Atlantic Current (NAC) forms one of the main component of the North Atlantic upper-layer circulation. It supplies a large amount of relatively warm and salty subtropical water to deep water formation sites, which constitute the starting point of the lower branch of the meridional overturning cell (MOC). Relatively cold and fresh waters of subpolar origin are also flowing along the northern side of the NAC, pointing out the relatively complex behaviour of this intergyre transport which feels both subtropical and subpolar gyre variability. Two main current branches, referred to as the northern and southern branches here after, are particularly observed above the Mid-Atlantic Ridge (MAR) and feed three distinct branches in the eastern subpolar gyre and an anticyclonic recirculation in the Iberian plain. Although the respective behaviours of the NAC components are tightly linked to strength of the MOC and its associated heat transport, they remain yet poorly documented.

We here use an ocean model simulation forced with interannual reanalysis fields (ORCA025-G70) along with a lagrangian analysis tool (ARIANE) to estimate the decadal variability of the circulation in the northern North Atlantic through a description of the NAC changes for the period 1965-2004. The complex spatial structure of the NAC current system is particularly considered through the respective variability of its distinct branches in the mid and eastern Atlantic basin. ARIANE is further used to investigate the changing composition of the current by separating the relative contribution of subpolar water (SPG) and subtropical water (STG) transports to the NAC branches.

Between the early 1970s and the mid 1990s, the positive trend of the North Atlantic Oscillation index (NAO) is associated with an intensification of the NAC above the MAR (25% of the mean transport), mainly induced by an increasing transport of its northern branch. This leads to a significant intensification of the cyclonic circulation in the mid Iceland basin and along the western flank of the Rockall Plateau. Meanwhile, the transport of the southern branch declines and impacts the transport intensity in the Rockall Trough. During the winter 1995/96, the NAO index switches to strongly negative value and the total NAC transport above the MAR subsequently declines (20% of the mean transport), while the opposing trends of the northern and southern branch reverse. Downstream, the circulation in the Iceland basin is reduced, although the increasing transport of the southern branch tends to damp the strong negative anomaly along the western Rockall Plateau. The circulation in the Rockall Trough remains rather low. The southward recirculation in the Iberian plain is exclusively linked to the southern branch upstream and presents no trends over the total period. This suggests that the decadal signals detected above the MAR are mainly transferred to the subpolar gyre.

In terms of SPG and STG contributions, the SPG contribution to the total NAC variability above the MAR describes a positive trend of relatively small amplitude between the early 1970s and the mid 1990s. The lagrangian analysis indeed reveals that the SPG transport exhibits positive and negative trends within the northern and southern branch, respectively. On the other hand, the impact of STG variability is large in both branches and mainly explains the total transport variability above the MAR over the whole period. Yet, the southward recirculation downstream in the Iberian plain is exclusively composed of STG waters, thereby increasing the relative proportion of SPG waters in the eastern subpolar gyre. Thus, the relative contribution of the SPG transport to the total variability is larger in this region and particularly affects the circulation in the mid Iceland basin and Rockall Trough.